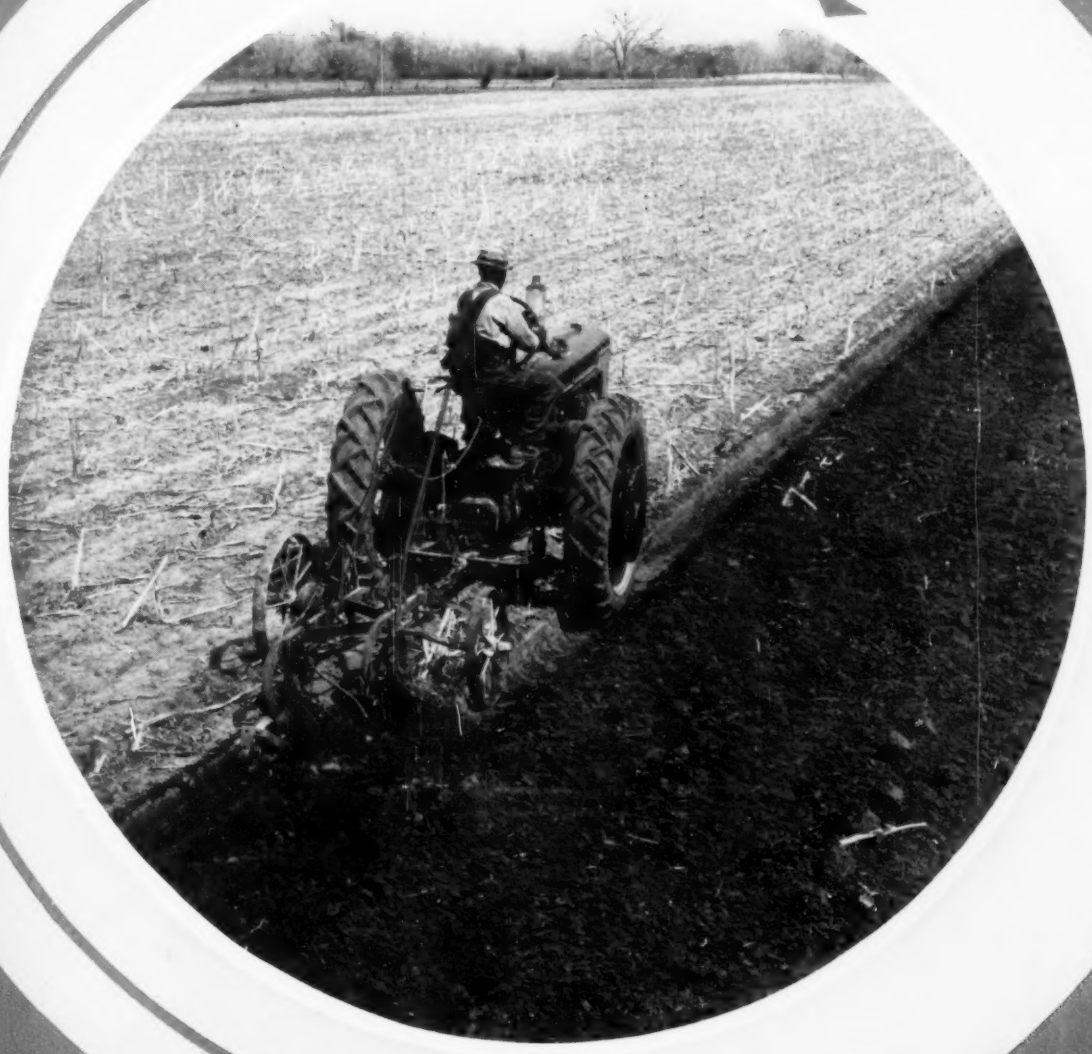
THE INSTITUTE SPOKESMAN



PUBLISHED BY THE
NATIONAL LUBRICATING GREASE INSTITUTE

VOLUME XI • NUMBER 5 • AUGUST, 1947

New Members

"The Institute Spokesman" is delighted to use its columns to welcome new members of the N. L. G. I. into the organization and at the same time call our reader's attention to the rapid growth of the Institute's membership. Six new members claim our attention and receive our cordial greeting in this issue of "The Spokesman."

The Canadian Oil Company, Ltd., P. O. Box 600, Petrolia, Ontario, Canada, joins the Institute as an Active Member. Mr. J. M. Allan is Chief Chemist of the company and supplies us with some interesting information about the Petrolia area as well as his company.

Oil was first produced in the Petrolia area in commercial quantities in 1858. Loyal Petrolians claim most vigorously that the well develop was in operation a year before the famous Drake well.

The first gusher was brought in in 1862 by a photographer named Shaw who developed a foot-power operated spring hole drill which reached oil in quantities at 165 feet.

The Canadian Oil Company, Ltd., formed in 1900 when a refinery was built just one mile north of Petrolia. This company expanded through Canada, branching out their sales territory from the Atlantic Ocean to the Rockies.

The National Refining Company of Cleveland, Ohio, acquired control in 1908. Expansion was steady until 1939 when Nesbitt Thompson Company and associates in Montreal bought control and since then the growth has been very rapid to keep pace with the demand of World War II and the post-war era.

The company has a very comprehensive line of greases and lubricants covering the automotive and industrial field in addition to many specialty products.

As a new Technical Member we welcome the Midwest Research Institute, 4049 Pennsylvania, in Kansas City 2, Missouri, whose President, Harold Vogtborg, was recently chosen as one of twenty-two American representatives from research, industry, and business to be entertained in the Scandinavian countries by the Royal Swedish Academy of Engineering Science, the Danish Academy of Technical Scientists, and the Federation of Norwegian Industries. Mr. Vogtborg and one other member of the American delegation was awarded the Silver Medal of the Royal Swedish Academy. The Midwest Research Institute is a non-profit scientific institute having the unique feature of being dedicated to the industrial development of Mid-America in addition to being an industrial research institute working for public and private organizations throughout the United States.

Currently, the Institute has under way approximately sixty research projects for American manufacturers, which projects are conducted on a confidential basis with all patentable developments accruing to the sponsor. In addition, it has fifteen regional projects under way directed toward the development of industrial uses of the agricultural and mineral resources of the area.

The Institute is completely equipped and staffed for research in the fields of agricultural, organic and inorganic chem-

Continued on Page 18

The INSTITUTE SPOKESMAN
Published monthly by
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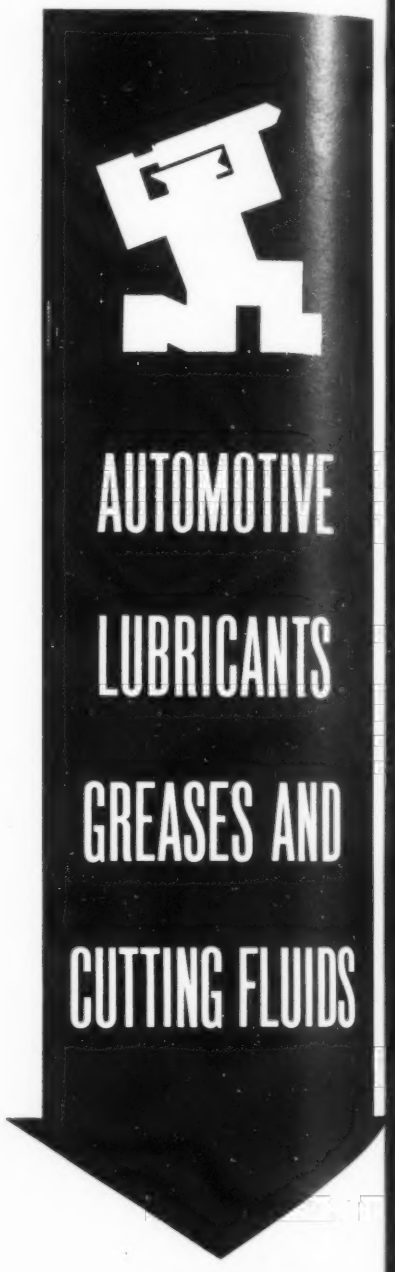

Modern Trends *in the Application of* Lubricating Greases

• By CHAS. I. KRAUS
Alemite Division of Stewart-Warner Corporation

Continued from June, 1947, Issue

The unit consists of a high pressure pump and a low pressure pump both of which are operated by compressed air obtained from the air compressor built into the unit. Here you see another type of portable unit in actual operation. Incidentally, these portable units provide the necessary air supply for operating spray painting units. An air supply for inflating tires where the service is highly desirable to the farmer.

We can hardly leave the subject of modern trends in lubrication without some mention of what is happening in the automotive field. Here, just as in industry, there have been many progressive changes made. Some of you may remember the days when you drove the family jalopy on to a lubrication hoist that looked something like this.

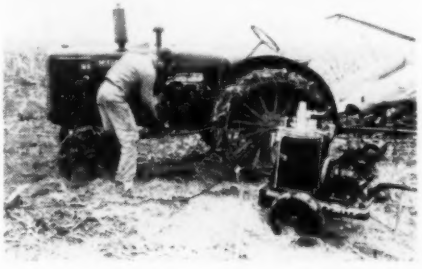

Figure 37

Figure 38

Modernization of lubrication equipment and facilities has brought out the added utility and new beauty . . . real glamour if you please, Hollywood style, and just where it will stop no one can foresee. As a matter of fact, modern automotive lubricating equipment is really more beautiful than the shiny new stove or refrigerator that you may be trying to get.

Figure 39

Continued on page 9

Mass Lubrication for Modern Mass Production

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Additives in Lubricating Greases*

By GUS KAUFMAN

The Texas Company, Technical & Research Division, New York, N.

The author stresses the importance of field tests in evaluating greases containing additives, since, he says, additives may not always be compatible, nor do they always have the same properties when used with different type bases. Some of the properties which may be improved by the use of additives in greases are load-carrying ability, greater resistance to oxidation, heat, water, and corrosion, better worked consistency, and improvement in rust prevention.

About the Author

Gus Kaufman was born on September 3, 1903, and was brought to Texas as an infant, residing most of the time in Houston, where he attended grade and high school. He received his degree of Bachelor of Science in Chemical Engineering with Distinction from The Rice Institute, Houston, Texas, in 1924.

Since then he has been connected with The Texas Company in the Technical and Research Division except for a time in the Port Arthur Refinery of The Texas Company. His first work in petroleum research embraced distillation and fractionation, and after plant work in this and grease manufacturing he was placed in charge of grease research at the Port Arthur, Texas, Laboratories and at the Beacon, N. Y., Laboratories. In 1941, he was transferred to the New York offices as Staff Technologist and then to his present position as Assistant to the Manager of the Technical and Research Division. He has, therefore, had over twenty years of experience in lubricating greases and allied products, which included all phases from the laboratory through the plant to the field. Of this time some thirteen years were spent in direct charge of grease research. He is the author of many patents and publications on lubricating greases, cutting oils, gear lubricants, and allied subjects.

THE subject of this paper appears to restrict it to a limited portion of grease technology. Actually, since lubricating greases are defined by the American Society for Testing Materials as "a semi-solid or solid combination of a petroleum product and a soap, or a mixture of soaps with or without fillers, suitable for certain types of lubrication," it is seen that this paper could embrace all that is known of greases. This is, of course, not practicable and only a limited portion of this information will be covered, particularly as it applies to the use of additives for improving certain properties of lubricating greases, such as:

1. Ability to maintain consistency on repeated workings and/or heating.
2. Ability to improve heat stability.
3. Ability to resist oxidation.
4. Improvement in load carrying capacity; that is, so-called extreme pressure characteristics.
5. Improvement in water resistance.
6. Improvement in rust prevention.

It will not be possible in some cases to be specific in defining the nature and composition of the additives used in view of the fact that many of these accomplishments are of a patentable nature. However, wherever possible specific names of additives have been given.

General Discussion

The simplest grease consists of soap added to oil. Now why do we add other materials to grease? Simply because the soap-lubricating oil compound may not have all the properties desired. At present many different kinds of greases are necessary to successfully meet various lubrication requirements. Additives and special compounding and manufacturing procedures are used, therefore, in an effort to reduce the number of greases to a minimum. Marked progress has been made. For example, in the aviation industry where dozens of greases have been used previously, the entire aircraft can now be lubricated by perhaps four or five greases, and there is a possibility that in the very near future this number may be reduced even further.

Before discussing means for improving the properties of greases by the use of additives and other means, it might be well to discuss some common misconceptions. For example, it is commonly stated that grease making is an art. Certainly it is anything but that. Few people realize that it is an accurate chemical process. Where else do you find manufacture controlled to an accuracy of one part in fifty thousand or one part in one-hundred thousand, and even one part in a million? For example, it is common practice to weigh to an accuracy of one pound or one-half pound in fifty thousand pounds. Then how has the misconception of the "art" in grease making come about? Well, the above statements on accuracy of manufacture apply to the chemical accuracy. However, grease makers must not only reproduce the same chemical compound, but its texture and looks must remain the same from batch to batch, and some art is required to do this. Secondly, since the soap-mineral oil combination results in a gel type of consistency which may change with working and with temperature, grease makers must predict fr the condition of the grease in the ket at the higher temperatures what it w do when it cools in packages. In t connection consistencies are, of cou taken at room temperature; that is, and it is realized that in actual operat the chances of a grease being required operate only at this one temperature very, very slight. This brings up other common misconception: that that if the grease is outside the particu specification set for it, whether it be manufacturer's specification or the b er's specification, it is no good. Let look at this a moment; for example us consider consistency. The maximu range now used by grease manufactur is thirty points by the ASTM worke penetration method for lubricat greases. The grease maker must, the fore, predict from the consistency of grease in the kettle what it will be w it is drawn, and the latter must co within the thirty-point range set up the classification system of the Natio Lubricating Grease Institute (NLG He must predict from the consistency the sample taken for control what ultimate consistency of the grease w be when drawn into different packa at different cooling rates. However, reproducibility of the test method its is only ± ten points, the latter f ure having recently been obtained a result of cooperative work done by Te nical Committee G of the American ciety for Testing Materials. Therefo the grease maker must draw the gre hot and predict its setting up to w narrow limits. In fact, allowing for reproducibility of the method, he only a very few penetration points work with. If the grease does not co within the thirty points permitted the NLGI, the grease must be dump However, the question that really co up is whether this narrow penetrat range for consistency is important, wh leads to the first phase of improvem

*Presented before the New York Section, A.S.L.E., January 30, 1947.

lubricating greases which will be discussed.

Consistency

When a new or improved grease is developed, its successful limits of operation are not limited to a consistency range of only thirty points. In most cases during the development of the product it was found to work satisfactorily over a much wider consistency range than thirty points; for example, fifty points or one hundred points, or even two hundred points in ASTM penetration. The consistency of the final grease is limited to the required NLGI thirty points primarily for greater uniformity and because of mechanical or operational limitations. For example, the particular grease gun available might not handle a wider range of consistency or the particular motor might not have sufficient power to turn if a wider-consistency product were used. The fact remains that the same grease functions from a lubrication standpoint over a wide range of consistencies. Therefore, reasonable limits for consistency are all that are necessary.

Let us see what has been done to "improve" or obtain the desired consistency over ranges of temperature and "workings" (that is, subjection to shear). One goal has been to develop a grease which would not soften after repeated workings or repeated subjection to shearing stresses. Normal greases show a spread of thirty to one hundred points between the ASTM unworked penetration and the worked penetration. Originally the goal was to make these two values approach each other. It was found that certain types of sodium soap greases and even specially prepared lime soap grease would do this. However, this is nothing to get excited about because the ASTM worked penetration represents only sixty workings through a ¼ inch orifice at room temperature which is usually not the operating temperature, but a bearing operating at say 3,600 rpm works the grease over 200,000 times in just one hour and over 200,000,000 times in 1,000 hours, a normal period before relubrication of anti-friction bearings. However, as a result of research in the use of additives and special methods of manufacture, it has been possible to develop greases which show practically no change in consistency with working as indicated by Grease B in Table I. It will be noted that although Grease A has a worked penetration of 285 after the standard 60 strokes, it becomes so soft as to make it impossible to take a penetration after 100,000 workings. However, Grease B, which has a penetration of 287 after the normal 60 strokes, has a penetration of only 288 after 100,000 workings.

TABLE I—CONSISTENCY VS. WORKING (RESISTANCE TO SHEAR)

	Grease A	*Grease B*
ASTM Penetration		
Unworked	265	267
Worked (Standard = 60 Strokes)	285	287
Worked 100,000 times	Too Soft*	288

*Penetration more than 420.

The desirability of the above property; that is, maintenance of the same consistency over wide ranges of conditions is manifested by now being required in important specifications. For example, Army-Navy Aeronautical Specification AN-G-15 General Purpose Grease requires that the grease resist working down, permitting a maximum penetration of 375 after 100,000 workings on the ASTM Grease Worker. Although considerable difficulties were first experienced in meeting this rather severe requirement, as indicatd above, this is now possible; in fact, Grease B above more

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than meets the requirement. From a practical standpoint there are operating conditions which require that a grease not work down, in particular where leakage is especially undesirable.

In an effort to obtain a constant consistency after working, grease manufacturers commonly resort to milling, but this may produce only a temporary effect, as is shown in Table II. It will be seen that the ASTM worked and unworked penetrations which are taken at 77F have been brought closer together by milling, but a few minutes of use, as in a ball or roller bearing, nullifies this as the small amount of heat generated causes the grease to revert more or less to its original consistency, and after working in a bearing it acts the same as it would if it had never been milled. Milling of a grease is usually carried out to reduce leakage, but it will be noted in Table II that this was not accomplished, the leakage for the milled grease being, if anything, slightly higher than the unmilled grease.

It must be recognized, however, that there are certain types of lubrication when it may be desirable to compound a grease in such a way as to have it work down and yet not leak out. For example, in certain anti-friction bearing applications it is desired to have flooded lubrication without leakage.

This is possible by the use of proper compounding ingredients, as is shown in Table III. It will be seen that Grease C works down much more than Grease D; yet no leakage was obtained with the former, whereas leakage was very bad with the latter. Grease C did not leak out in spite of the fact that it became very soft, which was possible by special compounding procedures. On the other hand, Grease D softened only slightly yet gave bad leakage. Grease E has been included in Table III to show that greases can be made with only slight softening and still give no leakage. Inasmuch as the mere resistance to working down is no indication of leakage tendency, the question naturally comes up as to what properties of the grease are responsible for leakage. This subject was discussed in a paper by the author published in *The Institute Spokesman*.

TABLE II—EFFECT OF MILLING ON CONSISTENCY[1]

	Unmilled	*Milled*
ASTM Penetration		
Unworked	195	309
Worked	299	328
Difference	104	19
Miniature Penetrations[2]		
Unworked	54	128
Worked	140	196
Difference	86	68
Miniature Penetrations on Grease after Running on Anti-Friction Bearing @ 1750 rpm—Maximum Temperature 156F		
Original Grease	54	128
Grease on Bearing	41-45	50-62
Grease which Leaked Out	98-100	91-93
% Leakage	17.2-19.0	22.8-23.7

[1] Taken from Paper Presented by Author before National Lubricating Grease Institute on October 4, 1938.

[2] Miniature Penetrometer for Determining the Consistency of Lubricating Greases—Gus Kaufman, W. J. Finn, R. J. Harrington *I.E.C., Anal.*, Vol. II, No. 2—February 19, 1939.

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TABLE III—CONSISTENCY VS. LEAKAGE

	Grease C	*Grease D*	*Grease E*
ASTM Penetration			
Unworked	255	250	265
Worked	430	275	280
Leakage from Ball Bearing Operating at 1750 rpm	None	35-40%	None
Penetration on Used Grease	Too Soft*	Only Slight Softening	Only Slight Softening

*Penetration more than 420.

(NLGI)—Volume II—No. 12—March, 1939. It was pointed out therein that one of the most important properties of a grease which causes leakage is texture. Other factors discussed were air entrainment and vaporization of volatile matter in greases.

Considerable space has been devoted to modifications in greases by the use of additives or by the choice of ingredients to obtain the desired consistency because consistency or changes in consistency is something which appears easy to understand. For that reason an importance has been attached to consistency completely out of line with its real importance. We hear of specifications requiring a ten to fifteen point range in consistency limits, and we hear of grease manufacturers who pride themselves by claiming such narrow limits of manufacture in spite of the fact that the method of taking penetrations itself is only accurate to ± 10 points. I would contend that if a grease must be made to such close consistency limits to function properly, it is no good. Also if a piece of equipment requires a lubricant of such close tolerances, it has not been properly designed. It is agreed that greases should be and are manufactured to close tolerances, but, in addition, they should function satisfactorily over wide ranges of tolerance. In most cases where impractical tolerances are specified for greases, the conclusions have been based on limited test data or inadequate or non-reproducible test information.

Heat Stability

One of the outstanding examples where additives have been successfully used is in improving the heat stability of lime soap greases, generally referred to as cup greases. These are probably the commonest greases made. The soap and oil are usually held together by water, this method having been used since their inception and still being used. However, in use if the temperature rises sufficiently high to vaporize the water, the usual cup greases break down into soap and oil. It is generally supposed that this will occur at a temperature corresponding to the boiling point of water. Actually ordi-

Continued on Page 10

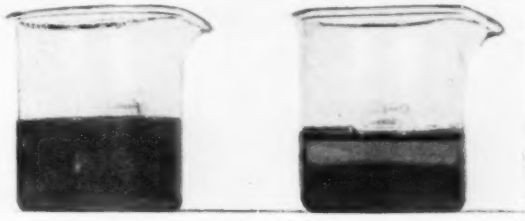

Figure 1. Comparison of stability to heating of heat-stable and non-heat-stable calcium soup greases.

Heat-stable calcium soup grease. Ordinary cup grease.

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President's Column . . .

H. P. Hobart, President N.L.G.I.

The 15th Annual Convention of the National Lubricating Grease Institute will be held at the Edgewater Beach Hotel in Chicago, October 16th, 17th and 18th, 1947.

With this Convention but a little more than 60 days away, it seems appropriate that we should devote this column to some brief remarks concerning the general plan and program. While all arrangements for papers to be presented are not yet complete the following preliminary information may be of interest at this time.

Thursday, October 16th. Members and guests will be given an opportunity to register in the main foyer. The same attractive young secretaries, Miss Davis, Miss Frank and Miss Paulson who so ably and cheerfully handled the Registrations at the Convention last year, will again serve in this capacity. The N.L.G.I. is indebted to the Pure Oil Company, the D. A. Stuart Oil Company and the Deep Rock Corp. for lending the time and services of these young ladies during the N.L.G.I. Convention.

At 11:00 A. M. the present N.L.G.I. Board of Directors will hold its final meeting of the year.

At 1:45 P. M. The Convention will be called to order and three technical papers are scheduled for the afternoon session. The first one is by Mr. Dale V. Stingley, of Armour & Co., Chicago, on "FATS, OILS AND FATTY ACIDS FOR INDUSTRIAL PURPOSES." The other two papers will be presented by men prominent in the industry on subjects of importance and interest. Arrangements have been made with each of the speakers who are presenting papers, to have pre-prints of their papers available at the Convention.

At 4:30 P. M. the Annual Business meeting of the Institute is scheduled which all Active Members are urged to attend. The Nominating Committee will report at this meeting and election of Directors for the ensuing year will follow. Other necessary items of business will be presented to the meeting for discussion and vote as may be required.

Thursday evening at 8:00 P. M., the second session of the Convention will convene and two papers will be delivered. One of them by Mr. Stanley Elliott of the Ferro Chemical Corp., Bradford, Ohio.

Friday, October 17th. The Friday morning session scheduled for 9:30 A. M. has three papers. A co-authored paper by Mr. Claude Johnson, President of the Jesco Lubricant, and Mr. J. A. Altshuler, Vice-President, Stratford Engineering of Kansas City, will be heard.

At noon, the new Board of Directors will hold an organizational meeting to elect officers and appoint committees for the ensuing year.

The Friday afternoon session starting at 2:00 P. M. will be devoted to the Technical Committee, who will hold a symposium on the same subject which engaged their interest and proved so stimulating last year, "PUMPABILITY OF GREASE AND DELIVERY CHARACTERISTICS OF DISPENSING EQUIPMENT."

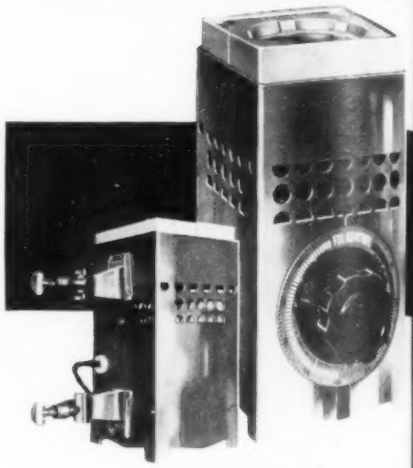
As is the Institute's custom, a cocktail party has been arranged for members and their guests at 6:15 P. M. in the West Lounge, to be followed by the Annual N.L.G.I. Banquet. The committee has departed from past practice this year in limiting the number of variety and entertainment acts. They have selected an outstanding pianist and vocalist who will play, sing and lead group singing during the banquet. The principal feature of the evening's entertainment will be a talk on "ATOMIC POWER" by Dr. H. D. Bass, head of the Department of Chemistry of the Purdue University of LaFayette, Ind.

Saturday, October 18th. The Saturday morning session will see a resumption of the Technical Committee and Symposium and final adjournment of the Convention will be around noon time, so that those in attendance will have plenty of time to catch their plane or train connections during the afternoon to be home Sunday.

It is not only my duty as President of N.L.G.I., but also my great pleasure, to issue this, the official call, for the 15th Annual Convention. Attendance is not limited to companies holding N.L.G.I. membership, guests are not only welcome, but are cordially invited.

Let me urge you to mark October 16th, 17th and 18th on your calendar and make the necessary arrangements to be in attendance. The officers will look forward to the pleasure of seeing you at the Convention and we ask that you introduce yourself.

TESTING ★ TOPICS ★



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MODERN TRENDS IN THE APPLICATION OF LUBRICATING GREASES

Continued from Page 3

Here are some typical examples of present day automotive lubricating equipment. From its appearance it may be hard to believe that it is lubricating equipment, but let me tell you that the performance of this glamourized equipment far exceeds the serviceability of similar equipment to the industry just few years ago.

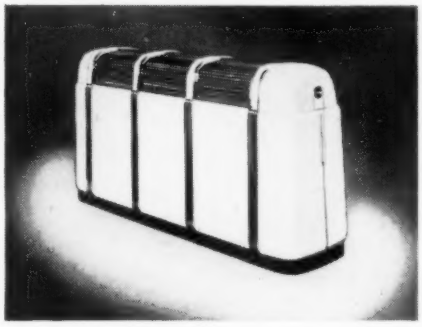

Figure 40

Figure 40 shows a battery of four lubricating pumps contained in a single unit. Normally this unit would contain

Figure 41

two high and two low pressure units, and it would be placed between two lubrication lifts in such a manner that two lubrication jobs could be handled simultaneously.

Figure 41 shows the individual portable high pressure pump opened up. It

Continued on Page 17

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ADDITIVES IN LUBRICATING GREASES

Continued from Page 7

nary lime soap greases will break down after heating at temperatures of the order of 160F; for example, in anti-friction bearings.

To obtain improved resistance to heat extensive research was carried out to determine what additives could be used which would not be lost at the elevated temperature. This problem was successfully solved and is covered by various patents issued and pending. These improved lime soap greases may be heated well above their melting points and above the boiling point of water and still not break down; in fact, they may be heated repeatedly without separating. Figure 1 shows this phenomenon.

Another example of improved heat resistance is the brick type of sodium soap greases as used on open journals where the grease must be solid, must touch the rotating shaft, and yet must not feed out too fast; for example, driving journals of locomotives. In this case, it is desired that the grease be firm to resist deformation and yet soft enough to permit feeding at temperatures which in the case of locomotives may reach sub-zero. Still the grease must remain firm when the journal heats up to 250F, and even 300F. Figure 2 shows how this was accomplished. Please note that although Grease F was softer at normal temperatures, which is a distinct advantage since it produces immediate lubrication, still it is many times harder than Grease G at elevated temperatures although Grease G was some three times harder than Grease F at room temperature.

It will be noted that in the example cited above no reference was made to the dropping points of these products in relation to heat stability. It is pointed out that melting point or dropping point bear no relation to heat stability in practice, which is well recognized by both

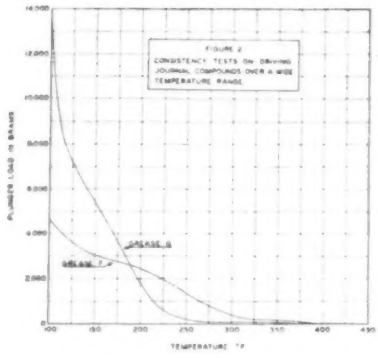

Figure 2

manufacturers and users of grease. The point is that the melting point or dropping point of a grease is merely the temperature at which one drop detaches itself from the remainder of the grease, using a specified type of receptacle for the grease. In fact, it has been possible to make greases having melting points of 600F and over; yet such products had very poor practical heat stability simply because the product may decompose during the running of the test, and the decomposition products may never drop through to give a true dropping point. Similarly pressure viscosity should not be used as an indication of heat stability since here the product is subjected to heat for only a short period of time and the viscosity of the grease bears no relation to practical heat stability. Here too if the product decomposes, a high viscosity will be obtained, which is, of course, meaningless from a practical standpoint.

Oxidation Stability

Hand in hand with heat stability comes oxidation stability. Advances have been truly beneficial. No little credit goes to the development of a simple accelerated test method to determine oxidation stability; that is, the Bomb Oxida-

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ion Test developed by Mr. F. L. Wright et al.[1,2] The details of this Bomb Oxidation Test method will not be covered in detail in this paper as it is well known to all and is now being considered for adoption by ASTM. Briefly, the bomb oxidation test determines the tendency for a grease to absorb oxygen, and, therefore, is an indication of its oxidation resistance. The grease is subjected in a bomb to an oxygen pressure of 110 psi and a temperature of 210F. The drop in pressure is then observed for different periods of time; a grease showing excellent oxidation resistance will usually have a pressure drop of less than ten pounds and in many cases less than five pounds in 100 hours. Greases showing low pressure drop usually have excellent storage stability.

[1] F. L. Wright & W. A. Lutz, *Product Engineering*, June, 1936, P. 210.
[2] F. L. Wright & H. A. Mills, *ASTM Proceedings*, Part II, 38, 525 (1938).

TABLE IV—OXIDATION RESISTANCE—NORMA-HOFFMANN BOMB OXIDATION TEST 210F—110 POUNDS OXYGEN PRESSURE

	Pressure drop, psi	
	100 Hrs.	*400 Hrs.*
Ordinary Lime Soap Grease	50+	
Lime Soap Grease Oxidation Inhibited	<5	<20
Sodium Soap Grease	15-25	30-50
Sodium Soap Grease Oxidation Inhibited	<5	<20
Sodium-Calcium Soap Grease	15-25	30-50
Sodium-Calcium Soap Grease Oxidation Inhibited	<5	<20

It has been possible to use additives in greases resulting in marked improvement in their resistance to oxidation. These anti-oxidants are usually of the organic amine type, and only small percentages are necessary to produce these improvements. Table IV shows the improvements possible. For example, an ordinary lime soap grease may show a pressure drop of as much as fifty pounds or more after one hundred hours at 110 pounds of oxygen pressure. However, by the use of oxidation inhibitors lime soap greases can be produced showing a pressure drop of less than five pounds in one hundred hours. In the case of sodium soap greases, lithium soap greases, mixed base greases, etc., similar improvements in oxidation resistance are possible by the use of inhibitors. One point which may be mentioned, however, is that although sodium

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soap greases made with residual oils, such as wheel bearing greases, may show somewhat high values by the Bomb Oxidation Test, in storage and in use they give satisfactory results.

Regarding the significance of the results, a value of less than five pounds pressure drop usually means that the grease can be packed in a bearing and kept in storage for several years without any deleterious effects upon the bearing. Therefore, better values than this have very little practical significance.

Also, it is emphasized that the Bomb Oxidation Test is intended as an accelerated means for predicting the resistance to oxidation of greases when stored in thin films, for example, on anti-friction bearings or the like; i. e., it is a static test and is not intended to predict practical dynamic performance. A dynamic oxidation test has been developed, and Figure 3 is a diagrammatic sketch of this test. By the use of this type of evaluating equipment it is possible to obtain accelerated oxidation information at about one-tenth of the time necessary with the static test. Before leaving the subject of oxidation tests it should be mentioned that in the early days the bomb oxidation test was run at 175F instead of 210F. One grease which gave entirely satisfactory results at 175F was then found to give very erratic results at 210F. Usually the results were poor. However, in storage under both summer and winter conditions bearings packed with this grease were entirely satisfactory after five years or more. However, this does not in any way detract from the value of the bomb oxidation test to predict storage ability, and its use is widely recognized. Further development work is necessary, however, on the dynamic oxidation test, particularly of an operational nature.

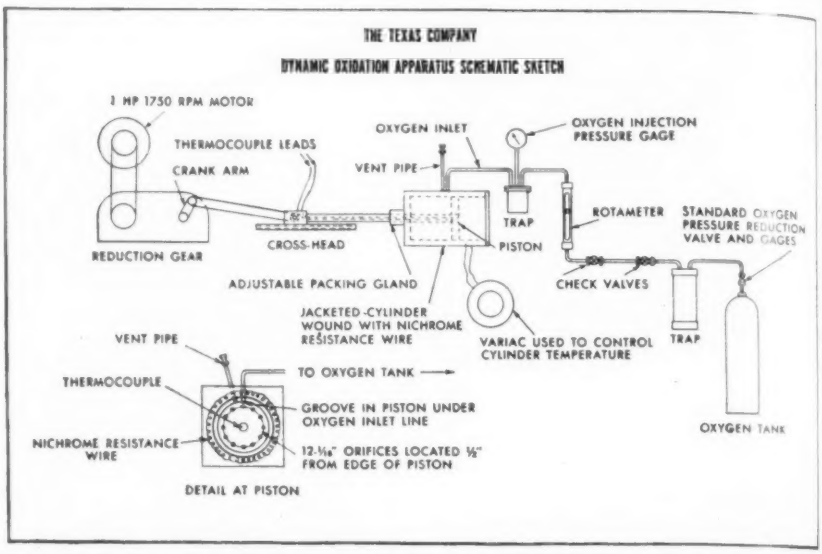

Figure 3. The Dynamic Oxidation Test which is used to distinguish between a grease with poor oxidation resistance and one with good oxidation resistance, also to evaluate the effect of oxidation inhibitors.

The apparatus consists essentially of a modified pump for rapidly evaluating oxidation characteristics of greases by repeatedly spraying grease into an atmosphere of oxygen under controlled conditions of temperature and pressure. This is accomplished by charging a sample of the grease to a closed cylinder equipped with a reciprocating piston provided with orifices, so that the sample is forced constantly from one end of the cylinder to the other. Since the grease is in constant motion, the dynamic method resembles actual service to a greater extent than static tests. Furthermore, the continuous agitation insures intimate and uniform contact between the entire sample and oxygen.

Extreme Pressure Characteristics

In general the extreme pressure (E.P.) characteristics of a lubricant are defined as the ability to carry load or maintain a film of lubricant between the rotating surfaces, thereby preventing seizure under heavy loads. Before discussing the use of additives to improve the extreme pressure characteristics of greases, a means of evaluating these characteristics must be considered. Many machines have been designed for this purpose, and al-

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though no one machine is acceptable as measuring and predicting extreme pressure characteristics under all conditions of service, each does serve a valuable purpose for evaluating load carrying capacity under certain specific conditions of operation; that is, although each machine may serve a specific purpose, none correlates with all conditions, and the question of which machine to use will depend upon service conditions and other considerations. For example, the SAE machine seems to indicate suitability under high speeds and low loads, including shock loads. The Timken Machine appears to indicate suitability under conditions of lower speeds, but higher loads. Also other machines are used, such as the Falex Machine, the Four Ball Machine, etc.

Without going into the advantages and disadvantages of each it might be mentioned that the Timken Machine is probably the most widely used for determining the extreme pressure characteristics of greases although other machines can and have been used. Considering the Timken Machine, an ordinary grease containing no additives; that is, extreme pressure agents, will usually carry a load of only five to fifteen pounds before scoring. By the use of additives and special compounding this can be raised to fifty pounds and more. In fact, it has been possible to obtain values approaching the limit of the Timken Machine; that is, eighty to one hundred pounds. The additives used are usually sulfur, sulfurized oils, chlorinated compounds, sulfur-chlorine treated materials, phosphorus compounds, phosphorus-sulfur compounds, lead soaps, etc. Only small percentages are usually required. In some cases an additive may not itself raise the extreme pressure characteristics of a grease, but in combination with another extreme pressure agent it may have distinct benefits.

Regarding the necessity for extremely high values on the extreme pressure machines, such as the Timken Machine, it is pointed out that even in severe steel mill gear service a Timken value of thirty-five to forty pounds has been found to satisfactorily protect the gears provided other properties of the grease, such as oxidation and heat resistance, are present in the grease. Although values as high as one hundred pounds have been reached on the Timken Machine, it would appear that such values are beyond practical significance, since the metal itself

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Figure 4. Car entering ford during splash tests.

Table V—Results of Inspection of Wheel Bearing

		Pressure drop lbs. per in.²
Car Name:	Plymouth	Bearing Type: Timken
Manufacturing Year:	1937	Tapered Roller
Model:	Sedan	Amount of Charge: 100 grams
	Right Wheel	*Left Wheel*
Lubricant	*Soda Soap Grease*	*Lime Soap Cup Grease (Water Resistant)*
ASTM Penetration	275	266
Outer Bearing	Small amount of grease on cage. Rollers oily, cup dry. Grease a greenish black color, oil sheen. No evidence of rust.	Very little grease on cage. Rollers oily, cup dry. Grease a yellow color. No evidence of rust.
Inner Bearing	Small amount of grease on cage. Rollers oily, cup dry. No evidence of rust. Grease a greenish black color with an oily sheen.	Very small amount of grease on cage. Grease on cage white. Evidence of water. Three rollers rusty, remainder oily. Three rust spots on cup.

will undergo deformation under such high loads. In addition, the use of trick materials to get these high values usually destroys or causes detriment to the other desirable characteristics of the grease.

Water Resistance

The user of grease should first analyze his problem and see if he really requires extreme resistance to water washing and whether greases having this property may not have other undesirable properties. For example, it has been shown by both laboratory and field tests that extreme resistance to water washing may also go hand in hand with a tendency towards corrosion and rust formation. It is not difficult to obtain water resistance by the use of special compounding and special additives. For example, lime soap greases are commonly used to obtain water resistance, whereas sodium soap greases are generally considered less resistant to water washing; in fact, when made with many fats, they tend to emulsify with water. However, experiments, carried out with a water resistant grease to which water had been added and with sodium soap, so-called water soluble grease, showed that the bearings packed with the water resistant grease were corroded very badly in less than three months, whereas the sodium soap grease was entirely satisfactory.

Another soap base giving water resistance is lithium. Also saturated fats give greater water resistance than do unsaturated fats. Fillers have also been used to obtain greater water resistance, but this is generally not recommended due to the abrasive action of most fillers. However, as stated above, the user should study carefully the problem involved before specifying extreme resistance to water washing since the latter is very often a detriment rather than a help.

As an example, a practical test was conducted to determine the resistance of soda soap grease (emulsifiable with water) to washing out of the lubricated parts in comparison with water resistant grease (lime soap cup grease). In the procedure chosen sodium soap grease on the one hand and lime soap grease on the other hand were used as lubricants for the wheel bearings and steering mechanisms of automobiles. The cars thus serviced were subjected to severe splashing tests through a stream which would simulate the worst wet-weather driving. One side of the car was lubricated with the sodium soap grease and the other with the lime soap or cup grease. The cars chosen for the work had odometer readings of 25,000 miles, and the original grease seals were used.

For the actual tests the cars were drive through a gravel bottomed ford acro a fast moving stream. At the time the test the water was about 15 inch deep, above the running boards of t cars. The ford was approximately 30 fe across. Each car was driven into t water at 15-20 miles per hour, the under side of the chassis being completely we Figure 4 shows one of the cars crossi the ford. The test consisted of ten tri across the creek and ten trips back. Aft

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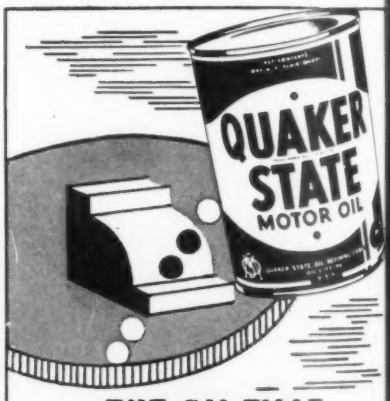

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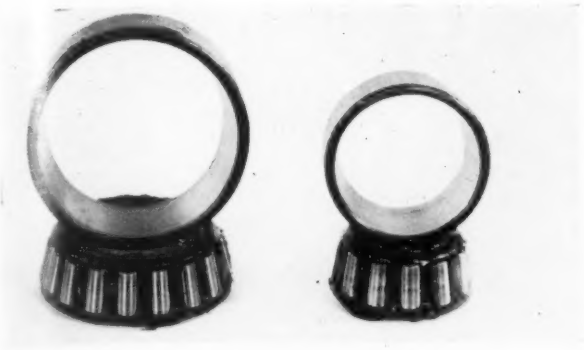
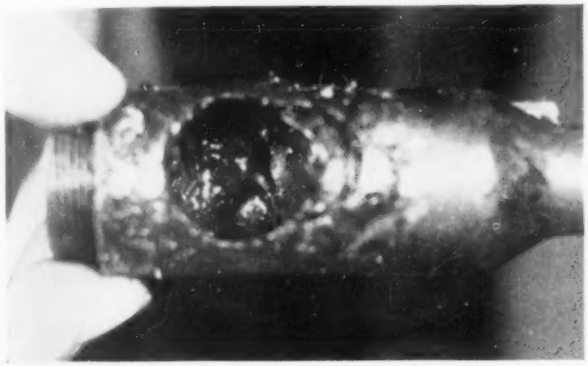
Figure 5—Tapered roller bearings after splash test.



Soda soap grease—right front wheel.
Inner bearing assembly. *Outer bearing assembly.*

Lime soap grease (water insoluble). Left front wheel.
Outer bearing assembly. *Inner bearing assembly.*

Figure 6—Effect of water on grease-lubricated drag links. Pontiac drag links.



Left End — Cup grease (water resistant) lubricated.

Right End — Soda Soap grease lubricated.

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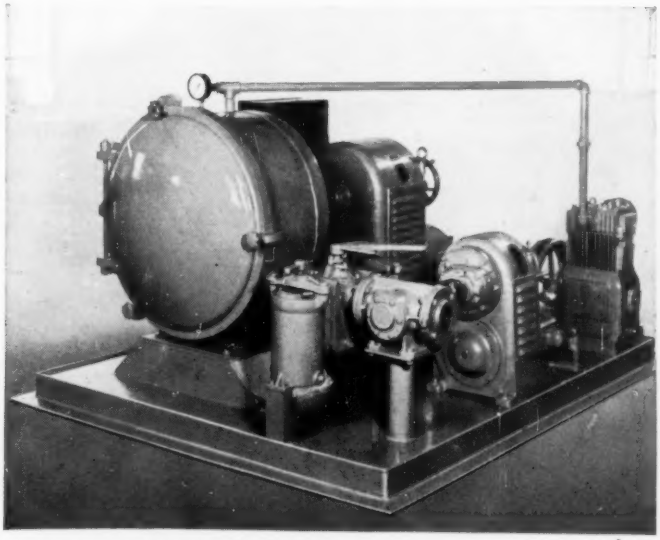

Grease Homogenizer, showing feed pumps, strainers and vacuum pump.

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Figure 7—Effect of water on grease—Lubricated tie rods. Plymouth tie rod.

Right End — Cup grease (water resistant) lubricated.

Left End — Soda Soap grease lubricated.

TABLE VI—EXAMINATION OF DRAG LINKS AND TIE RODS

Car Name: Pontiac	*Part Lubricated: Drag Link*	
	Right End	*Left End*
Lubricant	Soda soap grease	Lime soap grease Cup grease
ASTM Penetration (Original)	211	199
Color of Lubricant	Greenish black, oily sheen	Light tan
Texture	Fibrous	Mush like
Appearance of Enclosure	Excellent	Rust present
Exposed Sides	Oily	Dry and rusty
Car Name: Plymouth	*Part Lubricated: Tie Rod*	
	Left End	*Right End*
Lubricant	Soda soap grease	Lime soap grease
ASTM Penetration (Original)	211	Cup grease
Color of Lubricant	Dull brownish color	199 Light tan
Texture	Fibrous	Buttery
Appearance of Enclosure	Excellent	Some rust
Exposed Sides	Some grease and oil; no rust	Dry and rusty

this splash bath the cars were driven seven miles and allowed to stand for one week untouched. Results of the tests on one of the cars are given in Table V and in Figure 5. It will be seen that the soda soap grease lubricated bearings were well protected with no evidence of rust, whereas, those serviced with the water insoluble cup grease plainly showed rusting. It will also be noted that the wheel bearings lubricated with the sodium soap grease still had considerable grease left on the bearings; in fact, more than with the water insoluble lime soap cup grease.

Similar results were obtained on the drag links and tie rods, as given in Table VI and Figures 6 and 7. The soda soap lubricated ends of each part are full of lubricant with no trace of rust present, whereas those ends containing cup grease have some of the grease actually washed out and parts of the assembly showed considerable rust.

In other words under severe water conditions the sodium soap grease, which is more or less water soluble, supplied more and better protection to the tie rods and drag links than did the water resistant grease. Also the sodium soap grease offered superior lubrication to the wheel bearings than did the water resistant grease.

Rust Prevention

Especially during the war period, where conditions of operation were entirely different from normal peace-time operation, conditions of service existed where greases having rust preventive properties were necessary. It is well known that in war operations emergencies necessitated that entire equipment be immersed in water. Of course, such conditions as these do not exist in peace-time. However, considerable progress has been made in the use of additives to improve rust prevention. Of particular interest are the sulfonates, lead soaps, emulsifiers, etc.

Some government specifications are now requiring rust protection; for example, Naval Ordnance Specification OS-1350 General Purpose Grease requires that the product pass a salt spray test wherein a panel coated with the grease is

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subjected to salt spray for one hundred hours. By the use of special additives it is possible to meet this requirement. Army Ordnance Specification AXS-1169 Artillery Carriage Grease OD No. 00 also requires that the product pass this salt spray test; that is, no rust after one hundred hours at 95F.

Conclusions

Although it is possible by the use of additives to obtain a grease of almost any desired characteristic, it is stressed that many times the obtaining of this property may result in certain non-beneficial effects which may more than offset the benefits desired; that is, although it is possible to obtain a desired property by the use of a particular additive, other important properties of the grease may thereby be destroyed. Therefore, full evaluations and field tests must always be carried out to determine the overall significance of any indicated improvement by the use of additives. Another point is that the different additives required to produce the desired properties may not be compatible, and while one additive might produce the desired property with one soap base grease, it may not necessarily work with another soap base grease. Therefore, the incorporation of each additive necessitates complete re-evaluation for proof of quality.

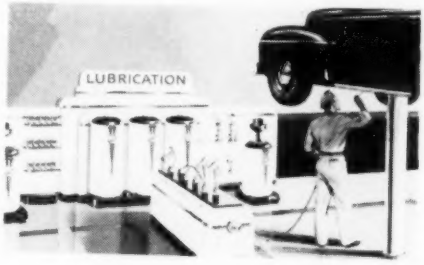
MODERN TRENDS IN THE APPLICATION OF LUBRICATING GREASES

Continued from Page 9

illustrates the manner in which lubricant drums are changed.

I would like to show you how this modern automotive equipment looks in its actual environment in the lubrication department. These typical installations will emphasize the fact that they contribute to customer eye appeal and showmanship which in reality has accounted for the trenedous growth and real success of the automotive service business.

Figure 42



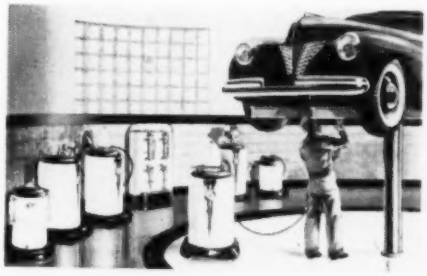


Figure 43

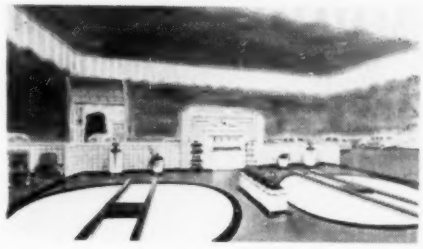


Figure 44

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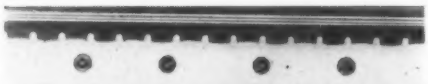

Figure 45

for handling and applying petroleum products. It is our hope that close cooperation between the producers of lubricating devices and the petroleum industry will help to make possible the improvements of tomorrow, many of which we cannot foresee at this moment. You have seen how these modern methods, procedures, and lubrication devices have contributed to industry, the contractor, the miner, the farmer and the automotive service industry. It is hoped that the progress so well established will continue at an ever-increasing rate to the mutual advantage of all of us engaged in the Petroleum Industry.

NEW MEMBERS

Continued from Page 2

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CONTAINER SPECIALISTS
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TIME REVEALS THE TRUTH—
Trophy grease is consistently made right
H. K. STAHL COMPANY
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The Pioneer Grease Manufacturer in the Upper Midwest

Membership.

The Southwest Petroleum Company is incorporated under the laws of the ate of Texas in 1934. From a modest ginning, it has shown steady growth, en through the depression years. It is de up of two divisions . . . one ecializing in selling Cactus Brand eavy Duty Lubricants direct to the nsumer and the second division known the Zone Company, specializes in sell- Zone Heavy-Duty Roof Coating. rritory includes every state in the Un- and, today, they are operating in ap- oximately thirty-five foreign countries.

The United States Air Compressor ompany, 5300 Harvard Avenue, Cleve- d 5, Ohio, Mr. F. J. Coughlin, Vice- esident in Charge of Sales, will be in tendance at future Institute meetings.

The United States Air Compressor mpany was organized in 1914 and rted immediately manufacturing air mpressor units. The company had ex- nded by adding to its products hy- ulic lifts, lubricating equipment, wes air couplers and air-line valves.

The company has twenty-four repre- tatives located in the principal cities the United States, is a member of the wmatic Automotive Equipment As- eumatic Automotive Equipment As- ciation, Automotive Lift Institute.

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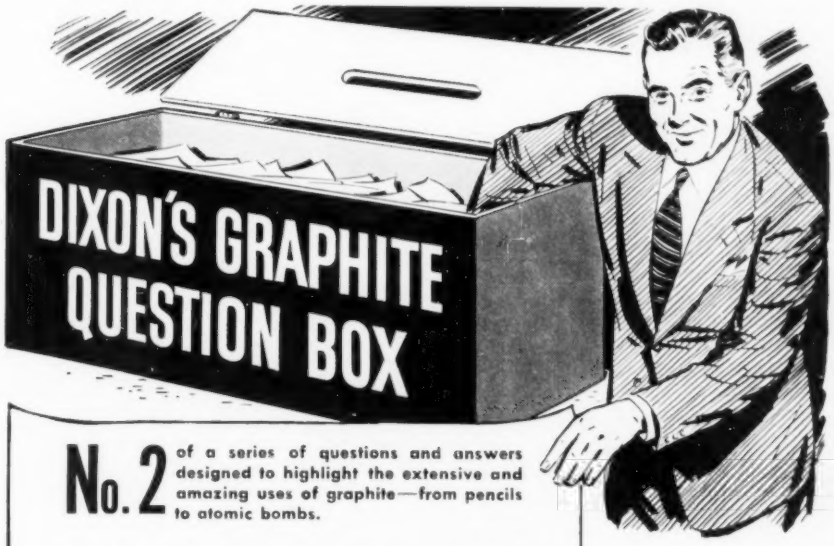


No. 2 of a series of questions and answers designed to highlight the extensive and amazing uses of graphite—from pencils to atomic bombs.

HELPFUL ANSWERS FOR TECHNICIANS AND PRODUCT ENGINEERS

QUES. What are the principal characteristics of graphite?

ANS. Extremely unctuous. Lustrous and opaque. Withstands excessively high and low temperatures. Fusibility unknown but probably about 3000° C. Combustible in the presence of oxygen at about 620° C., but not altered by heating in a vessel free from air. Chemically inert. Good electrical and heat conductivity. Low co-efficient of expansion. Non-magnetic, non-fusible, non-toxic, non-odorous, and does not permanently stain. Specific gravity: 2.1 to 2.3. Moh's scale of hardness: less than 1.

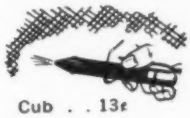
QUES. What are *some* of the products or processes in or on which graphite is used?

ANS. Tungsten and molybdenum wire filaments
Steam and internal combustion engine cylinder lubricants
Hydraulic pump piston and piston rod lubricants
Extreme heat-and-pressure-resisting lubricants
Mechanical packings and gaskets, washers and sealing rings
Pipe joint compounds and seals
Brake linings
Paper (lubricating and transfer)
Typesetting machine mold, space band and mouthpiece lubricant
Wire drawing
Oil-less, self-lubricating bearings
Transmission chain lubricant
Transmission rope and cordage lubricants
Trolley wire lubricants
Protective surface coatings with lubricating qualities
Impregnated lubricating metals, plastics, rubber, felt, fabrics, leather, paper and wood
Lubricating bearing paste
Mechanical oven, lehr and kiln chain lubricants
Metal stamping, forging, tumbling and assembling lubricants
Lathe dead center and steady rest lubricant
Rolling mill lubricants
Quarry and mine machinery lubricants
Coal mine machinery lubricants
Lock lubricants
Firearm action and barrel lubricants
Cycle chain lubricant
Piano action and organ assembly lubricants

(To be continued in No. 3)

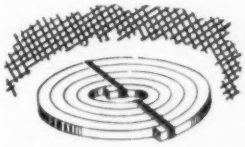
A few of thousands of widely used products containing Dixon's Graphites. Those starred are Dixon's products, many of them sold by supply houses everywhere.

★Microfyne Flake Graphite



Cub . . 13¢

Type 4 . 40¢
★Graph-Air Guns



Mechanical Packings

Now may we receive *your questions* on how graphite can help *you*?

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